INTEGRAL SUN GEAR COUPLING

CROSS-REFERENCE TO RELATED APPLICATION(S)

This application is a divisional application of U.S. patent application Ser. No. 11/391,764 by Loc Duong, Michael E. McCune, and Louis J. Dobek, entitled "EPICYCLIC GEAR TRAIN INTEGRAL SUN GEAR COUPLING DESIGN," filed on Mar. 22, 2006 now U.S. Pat. No. 7,591,754, which is hereby incorporated by reference. Further, U.S. patent application Ser. No. 12/536,650 by Loc Duong, Michael E. McCune, and Louis J. Dobek, entitled "METHOD OF MAKING INTEGRAL SUN GEAR COUPLING," filed on even date with this application, is a divisional application of U.S. patent application Ser. No. 11/391,764 by Loc Duong, Michael E. McCune, and Louis J. Dobek, entitled "EPICYCLIC GEAR TRAIN INTEGRAL SUN GEAR COUPLING DESIGN," filed on Mar. 22, 2006.

BACKGROUND

This invention relates to planetary gear trains. More particularly, the invention relates to a coupling system for flexibly connecting a sun gear to a rotating shaft so that the reliability and durability of the gear system components are improved. The invention is useful in aircraft engines where reliability, durability and simplicity are highly desirable.

Planetary gear trains are mechanical structures for reducing or increasing the rotational speed between two rotating shafts. The compactness of planetary gear trains makes them appealing for use in aircraft engines where space is at a premium.

The forces and torque transferred through a planetary gear train place tremendous stresses on the gear train components, making them susceptible to breakage and wear, even under ideal conditions. In practice, conditions are often less than ideal and place additional stresses on the gear components. For example, the longitudinal axes of a sun gear, a planet carrier, and a ring gear are ideally coaxial with the longitudinal axis of an external shaft that rotates the sun gear. Perfect or ideal coaxial alignment, however, is rare due to numerous factors including imbalances in rotating hardware, manufacturing imperfections, and transient flexure of shafts and support frames due to aircraft maneuvers. The resulting parallel and angular misalignments impose moments and forces on the gear teeth, the bearings which support the planet gears in their carrier, and the carrier itself. The imposed forces and moments accelerate gear component wear and increase the likelihood of component failure in service. Thus, accelerated component wear necessitates frequent inspections and part replacements which can render the engine and aircraft uneconomical to operate.

The risk of component breakage can be reduced by making the gear train components larger and therefore stronger. Increased size may also reduce wear by distributing the transmitted forces over correspondingly larger surfaces. However, increased size offsets the compactness that makes planetary gear trains appealing for use in aircraft engines, and the corresponding weight increase is similarly undesirable. The use of high strength materials and wear resistant coatings can also be beneficial, but escalates the cost of the gear train and therefore reduces its desirability.

Stresses due to misalignments can also be reduced by the use of flexible couplings to connect the gear train to external devices such as rotating shafts or nonrotating supports. For example, a flexible coupling connecting a sun gear to a drive shaft flexes so that the sun gear remains near its ideal orientation with respect to the mating planet gears, even though the axis of the shaft is oblique or displaced with respect to a perfectly aligned orientation. Many prior art couplings, however, contain multiple parts which require lubrication and are themselves susceptible to wear. Prior art couplings may also lack adequate rigidity and strength, with respect to torsion about a longitudinal axis, to be useful in high torque applications. Misalignment can also be accommodated by a splined connection. However the motion that occurs between the contacting spline teeth in a splined connection creates friction which is highly variable and causes the flexibility of such a connection to also be variable.

In view of these shortcomings, a simple, reliable, coupling system for connecting components of a planetary gear train to external devices while accommodating misalignment there between is sought.

SUMMARY

An integral sun gear and coupling assembly has a sun gear and a spindle that is connected at a forward end to the sun gear, and a rearward end to a shaft of a planetary gear train. The spindle has at least one undulant flexible section for accommodating misalignment between the sun gear and the shaft. The flexible section has a cylindrical ring having a diameter greater than the diameter of an adjacent section of the spindle, and is joined to the spindle by two longitudinally spaced apart diaphragms. The junctures between the diaphragms and the spindle are curved in cross section on an outer side of the diaphragms to improve flexibility and minimize stress concentrations. The inner sides of the diaphragms are a straight edge perpendicular to a central axis of the shaft which result in non-symmetric contour of the diaphragm walls.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic cross-sectional side elevation view of a turbine engine containing a planetary gear train.

FIG. **2** is a cross-sectional elevation view of a coupling system for the planetary gear system of the present invention.

FIG. **3** is a cross-sectional elevation view of an undulant flexible section of the present invention.

DETAILED DESCRIPTION

FIG. **1** shows a typical turbine engine **10** known in the art, which includes as its principal components one or more compressors **12**, **14**, one or more turbines **16**, **18** for powering compressors **12**, **14**, combustion chamber **20**, fan **22**, primary exhaust **24** and fan exhaust nozzle **26**. A power train such as shafts **28**, **30** extends from each turbine **16**, **18** to drive the corresponding compressor **12**, **14**. The rotary motion of one of compressors **12**, **14** is conveyed to fan **22** by way of planetary gear train **32**. Planetary gear train **32** reduces the rotational speed of a compressor to a speed more suitable for the efficient operation of fan **22**. The principal engine components are ideally concentric with central longitudinal axis **34**.

FIG. **2** is a cross-sectional elevation view of an integral coupling system **40** for planetary gear system **32** of FIG. **1**, and its relationship to engine **10**. Integral coupling system **40** comprises inflexible spindle **42** and at least one undulant flexible section **44** which rotate about central longitudinal axis **34**.

Also illustrated are compressor drive shaft **28**, planet gear **46**, ring gear **48**, ring gear housing **50**, ring gear coupling **52**,